PERFORMANCE OF STONE MASTIC ASPHALT INCORPORATING CELLULOSE FIBER

NURUL AIN NAJWA BINTI MD FAUZI

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : NURUL AIN NAJWA BINTI MD FAUZI

ID Number : AA15181

Date : 31 MAY 2019

PERFORMANCE OF STONE MASTIC ASPHALT
INCORPORATING CELLULOSE FIBER

NURUL AIN NAJWA BINTI MD FAUZI

Thesis submitted in partial fulfillment of the requirements
for the award of the
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering & Earth Resources

UNIVERSITI MALAYSIA PAHANG

MAY 2019

ACKNOWLEDGEMENTS

Alhamdulillah. Thanks to Allah SWT, whom with His willing gave me the opportunity to complete this Final Year Project called Performance of Stone Mastic Asphalt incorporating with Cellulose Fiber. This final year project report was prepared for Civil Engineering and Earth Resources, University Malaysia Pahang (UMP), basically for a final year student to complete the undergraduate program leading for B. Eng (Hons.) Civil Engineering. This thesis was referred to as the guidelines given by the university.

Firstly, I would like to express my special thanks of gratitude as my supervisor, Dr. Khairil Azman bin Masri, who had guided me a lot of tasks during two semesters session in 2018/2019. I would also like to extend my gratitude to the lecturers and staffs of Faculty Civil Engineering for their cooperation during complete the final year project that had given valuable information, suggestions, and guidance in the compilation and preparation this final year project report.

Deepest thanks and appreciation to my both parents, Md Fauzi bin Kasrun and Zubaidah Binti Shukor, to a special mate of mine, Mohd Aliff bin Masiran, and others for their cooperation, encouragement, constructive suggestion and full of support for the report completion, from the beginning till the end. Also thanks to all of my friends and everyone, that have been contributed by supporting my work and help me during the final year project progress till it is fully completed.

Last but not least, thanks to Faculty Civil Engineering and Earth Resources, UMP, and also my Academic Supervisor, Dr. Sharifah Maszura Binti Syed Mohsin, for great commitment and cooperation during my journey to complete this thesis.

ABSTRAK

Stone Mastik Asfalt (SMA) terkenal sebagai yang tinggi kandungan agregat kasar yang saling kunci untuk membentuk satu rangka batu yang menentang perubahan bentuk kekal. Walau bagaimanapun, ia menghadapi banyak masalah seperti aluran dan pelucutan kerana suhu yang tinggi dan berulang beban paksi (Zulhaidi et al., 2018). Ia juga mempunyai rayapan dalam beban dan suhu yang berbeza. Serat selulosa boleh meningkatkan kelikatan asfalt diubahsuai. Oleh itu, tujuan kajian ini adalah bertujuan untuk menggunakan gentian selulosa kekuatan tegangan yang tinggi untuk mengatasi masalah yang berkaitan dengan SMA. Penambahan serat selulosa ke dalam asfalt kawalan meningkat keupayaan pemulihan bitumen. Kertas kerja ini membentangkan hasil siasatan makmal ke atas Marshall Kestabilan, Resilient Modulus, Creep dinamik dan Cantabro Kehilangan lelasan Stone Mastic Asphalt (SMA) yang digabungkan dengan gentian selulosa pengikat diubah suai. Penembusan Gred 60-70 (PEN60-70) jenis pengikat telah bercampur dengan serat selulosa 0%, 0.2%, 0.3%, 0.4%, 0.5% dan 0.6% mengikut berat campuran. Campuran telah diuji untuk lelasan, Marshall Kestabilan, Resilient Modulus dan Dinamik Creep untuk menilai prestasi SMA diubah suai. Daripada keputusan, ia menunjukkan bahawa kewujudan serat selulosa mampu meningkatkan prestasi campuran asfalt, dan penambahan 0.2% serat selulosa menyumbang kepada nilai terendah lelasan, 0.4% serat selulosa menghasilkan ketumpatan yang tinggi, manakala 0.3% menghasilkan nilai tertinggi modulus berdaya tahan dan rayapan dinamik, 0.2% untuk kestabilan dan 0.4% untuk ketegangan. Untuk kajian masa depan, menguji untuk menganalisis kelakuan fizikal SMA dengan adanya serat selulosa untuk membuktikan keandalannya dalam pelbagai aplikasi dalam campuran asfalt.

ABSTRACT

Stone mastic asphalt (SMA) is well known as a high coarse aggregate content that interlocks to form a stone skeleton that resist permanent deformation. However, it facing a lot of problems such as rutting and stripping because of the high temperature and repeated axial load (Zulhaidi *et al.*, 2018). It also have creep in different loads and temperatures. The cellulose fibre can improve the viscosity of the unmodified asphalt. Thus, the aim of this study is intended to utilize the cellulose fiber high tensile strength to overcome the problem that is related to SMA. The addition of cellulose fiber into the control asphalt improved the recovery ability of asphalt binder. This paper presents the outcome of a laboratory investigation on Marshall Stability, Resilient Modulus, Dynamic Creep and Cantabro Loss Abrasion of Stone Mastic Asphalt (SMA) that incorporated with cellulose fiber modified binder. Penetration Grade 60-70 (PEN60-70) types of binder were mixed with cellulose fiber of 0%, 0.2%, 0.3%, 0.4%, 0.5% and 0.6% by weight of mixture. The mixtures were tested for Abrasion, Marshall Stability, Resilient Modulus and Dynamic Creep in order to evaluate the performance of modified SMA. From the results, it shows that the existence of cellulose fiber is capable of enhancing the performance of asphalt mixture, and the addition of 0.2% cellulose fiber contributes to lowest value of abrasion,0.4% cellulose fiber produce the high density, while 0.3% producing highest value of resilient modulus and dynamic creep, 0.2% for stability and 0.4% for stiffness. For future study, it is recommended to analyses the physical behaviour of SMA with the existence of cellulose fiber in order to prove its reliability in various applications in asphalt mixture.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

g	Gram
mm	Milimeter
^{o}C	Celcius
%	Percent
min	Minute
s	Second
o	Degree

LIST OF ABBREVIATIONS

SMA	Stone Mastic Asphalt
HMA	Hot Mastic Asphalt
DGA	Dense Graded Asphalt
OFC	Optimum Fiber Content
JKR	Jabatan Kerja Raya
AIV	Aggregate Impact Value
ACV	Aggregate Crushing Value
RAP	Reclaimed Asphalt Pavement
PA	Porous Asphalt
PCC	Portland cement concrete
PE	Polyethylene
PP	Polypropylene
EVA	Ethylene–vinyl acetate
EBA	Ethylene–butyl acrylate
SBS	Styrene–butadiene–styrene
SIS	Styrene–isoprene–styrene
SEBS	Styrene–ethylene/butylene–styrene
BS	British Standard
VTM	Voids in Total Mix
VFA	Voids in Filled Asphalt
LA	Los Angeles
UTM	Universal Testing Machine

CHAPTER 1

INTRODUCTION

1.1 Background of study

Stone Mastic Asphalt (SMA), which has been utilized in Europe for around 40 years ago, was to begin with created to supply resistance to scraped spot by studded tires (Woodward et al., 2016). Within the 1970s, studded tires were prohibited in Germany, and the utilize of SMA blends declined since of the higher material and construction costs and there now not showed up to be a basic require for these mixtures (Brown, 1992).

Rutting of Hot Mix Asphalt (HMA) got to be a greater issue in Germany within the 1980s due to increased tire weight, wheel loads, and activity volume, and SMA mixtures started to be used again (Brown, 1992). Studded tires have kept on be utilized in Sweden, and SMA blends have proceeded to provide great execution beneath these extreme stacking conditions. Other European nations have used SMA mixtures with comparable victory to that observed in Germany and Sweden.

Stone Mastic Asphalt (SMA) which basically involves higher extent of coarse total, lower extent of moderate size total and higher extent of mineral filler contrasted with conventional blends is utilized (Panda, Suchismita and Giri, 2013). SMA has a high coarse total substance that join to construct a stone skeleton that withstand permanent deformation (M.A, 2018). The sweeping whole of coarse totals inside the mix frames a skeleton-type structure giving a superior stone-on-stone contact between the coarse total particles, which offers high protection from rutting.

The SMA mixtures give an unpleasant macro texture, forming small path between the coarse aggregate, which valuable for a productive surface drainage (Panda, Suchismita and Giri, 2013). The voids of the asphalt mastic are loaded up with a high consistency bituminous mastic of bitumen and aggregate, to which strands are included in arrange to supply agreeable stability of the bitumen and to anticipate drainage of the binder amid transport and placement. (Woodward et al., 2016).

Figure 1.1 Cross section of Stone Mastic Asphalt

Sources: M. A (2009).

The deformation resistant capacity of SMA originates from a coarse stone skeleton giving more stone-on-stone contact than with standard dense graded asphalt (DGA) blends. Improved folio sturdiness could be an aftereffect of higher bitumen substance, a thicker bitumen film and, lower of voids substance. This high bitumen content additionally makes progress of flexibility. Expansion in addition of cellulose or mineral fiber as addictive in asphalt mixture can prevents drainage of bitumen amid transport and placement. There are no exact design rules for SMA mixes (M.A, 2018). The essential features, which are the coarse total skeleton and mastic organization, and the following surface texture and mixture stability, are to a great extent chosen by the choice of total grading and the sort and extent of filler and cover.

1.2 Problem Statement

Since Malaysia is located in the tropical region with temperature, high humidity and copious rainfall throughout the year, it causes damage of road pavement (Zulhaidi *et al.*, 2018). Hence, the asphalt concrete facing a lot of problems such as rutting, moisture stripping and binder drain down. Subsequently, the mixture’s resistance to moisture damage and rutting specifically will effects the life span of the paving mixture.

Further more, the heavy traffic load also tends to influence the performance of asphalt mixture in terms of its resilient modulus and dynamic creep. A common method to overcome these problem is by modifying the asphalt binder properties by adding the cellulose fiber with Stone Mastic Asphalt (SMA). Since fiber tends to provide improvement of the properties for asphalt, this study aim to promote the cellulose fiber as asphalt binder modifier in order to enhance the properties of asphalt mixture.Rutting is a pavement distress instrument that can significantly affect the ride-ability, asphalt judgment and safety that's a common indication of ‘aqua planning’ on a road surface. The form of fatigue cracking in asphalt and embedment in spray seals, regularly too followed by surface failure.

Drain down is determined when mixture (fines and bitumen) that isolated itself from the sample and flows downward through the mixture (NAPA, 2017). The main problems with SMA mixtures are drainage and bleeding. In order to control these problems, storage and placement temperatures can not be lowered due to the difficulty in obtaining the required compaction. Stabilizing additives have therefore been added to improve the mastic, reduce the drainage of the mixture at high temperatures and achieve even higher binder content for increased durability (NAPA, 2017).

1.3 Objectives of study

The aim of this study to enhance the properties of SMA in terms of resilient modulus, dynamic creep, Marshall stability and Cantabro Loss with the existence of fibre content. Among the objectives are;

1. To evaluate the mechanical performance of cellulose fiber – stone mastic asphalt (SMA) interms of resilient modulus, dynamic creep, Marshall Stability and Cantbro Loss.

2. To determine the optimum fiber content (OFC) cellulose fiber modified asphalt binder SMA20.

REFERENCES

AAPA (2002) 'Stone Mastic Asphalt Surfacing', pp. 1–3.

Arshad, A. K., Masri, K. A. and Ahmad, J. (2017) 'SCIENCE & TECHNOLOGY Investigation on Moisture Susceptibility and Rutting Resistance of Asphalt Mixtures incorporating Nanosilica Modified Binder', 25, pp. 19–30.

Adam, M. C (2013) 'Porous Asphalt'.

Brown, E. R. (1992) 'Designing Stone Matrix Asphalt Mixtures for Rut-resistant Pavements - E_ Ray Brown, National Cooperative Highway Research Program - Google Books'.

Becker, Y (2011) 'Polymer Modified Binder'.

C. Syrrakou, J. F (2010) 'Porous Pavement Hydrology',(*World Environmental and Water Resources Congress. ASCE Library,* pp. 994-1001.

C.A. Michele, H. T (2004) 'Infiltration BMPs-Porous Asphalt Pavement and Beyond',World Water & Environmental Resources Congress', pp. 1 - 13.

Elswick, F (30 June, 2017) '4 Benefits of porous pavement', *Midwest Supply Industrial.*

Greer, G. (2006) 'Stone Mastic Asphalt – A review of its noise reducing and early life skid resistance properties', *Proceedings of ACOUSTICS*, (November), pp. 319–323.

G. Polacco, S. B (2005) 'Asphalt modification with different polyethylene-based polymers'.

Hainin, R., Reshi, W. F. and Niroumand, H. (2012a) 'The importance of stone mastic asphalt in construction', *Electronic Journal of Geotechnical Engineering*, 17 HR(January 2012).

Hainin, R., Reshi, W. F. and Niroumand, H. (2012b) 'The importance of stone mastic asphalt in construction', *Electronic Journal of Geotechnical Engineering*, 17 HR(February).

Hasamudin, W. W. H. and Soom, R. M. (2002) 'Road making using oil palm fiber', *Malaysian Palm Oil Board Information Series*, 171(May), pp. 3–6. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Road+making+using+oil+palm+fibre#0.

Interactive, P (2010) ‘Mix Types - Pavement Interactive’.

Jan E.G. van Dam, C. M. D. M. (2018) ‘sciencedirect-topic-bamboo-fiber.pdf’.

JKR (2008) ‘JKR/SPJ/2008-S4’, *Standard Specification for Road Work*.

Kumar, P., Chandra, S. and Bose, S. (2007) ‘Laboratory investigations on SMA mixes with different additives’, 8(1), pp. 11–18. doi: 10.1080/10298430600987381.

Liu, Q. a (April, 2009) ‘Research on Material Composition and Performance’, Constr. Build. Mater, pp. 135–140.

Lu, X (1997) ‘On polymer modified road bitumens [doctoral dissertation]’.

M.A, M. I. (2018) ‘STONE MASTIC ASPHALT’.

Muench, S. (2006) ‘Pavement Design’.

MacDonald, C (2006) ‘Porous Pavements Working in Northern Climates’.

Mahmoud Enieb, A. D (2016) ‘Overview Stone Mastic Asphalt’.

NAPA (2017) ‘Drain Down Characteristics’, pp. 125–131.

O’Flaherty, C. A. (2007) ‘Introduction to pavement design’, *Highways*, pp. 225–266. doi: 10.1016/b978-075065090-8/50011-9.

Panda, M., Suchismita, A. and Giri, J. P. (2013) ‘Utilization of Ripe Coconut Fiber in Stone Matrix Asphalt Mixes’, *International Journal of Transportation Science and Technology*. Tongji University and Tongji University Press, 2(4), pp. 289–302. doi: 10.1260/2046-0430.2.4.289.

Prof. B. E. Gite, M. M. S. A. A. (2019) ‘Stone Mastic Asphalt’, pp. 1–9.

Putman, B. J. (2011) 'Effects of Fiber Finish on the Performance of Asphalt Binders and Mastics', *Advances in Civil Engineering*, 2011, pp. 1–11.

Pellinen, P (2016) 'CIV-E1010 Building Material Technology ,HMA', Aalto University.

Q.T. Liu, E. S (2011) 'Mechanical properties of sustainable selfhealing porous asphalt concrete'.

Res, T. J. (2008) 'Nanotechnology and Drug Delivery. Tropical Journal of Pharmaceutical Research'.

Raman Bharath, V. R., Vijaya Ramnath, B. and Manoharan, N. (2015) 'Kenaf fibre reinforced composites: A review', *ARPN Journal of Engineering and Applied Sciences*. Elsevier Ltd, 10(13), pp. 5483–5485. doi: 10.1016/j.matdes.2011.04.008.

Sharma, S. (2016) 'THEORY OF FLEXIBLE PAVEMENT ':

S. Tayfur, H. O (2007) 'Investigation of rutting performance of asphalt mixtures containing polymer modifiers'.

Schäfer, L. D (2005) 'Stone Mastic Asphalt'.

Tighe, J. Y (2013) 'A Reviw of Advances of Nanotechnology in Asphalt Mixtures'.

Vaitkus, A. *et al.* (2017) 'Asphalt wearing course optimization for road traffic noise reduction', *Construction and Building Materials*. Elsevier Ltd, 152, pp. 345–356. doi: 10.1016/j.conbuildmat.2017.06.130.

Vaitkus, A. and Paliukaite, M. (2013) 'Evaluation of time loading influence on asphalt pavement rutting', *Procedia Engineering*. Elsevier B.V., 57, pp. 1205–1212. doi: 10.1016/j.proeng.2013.04.152.

White, G. *et al.* (2017) 'Framework for a Pavement-Maintenance Database System', *Framework for a Pavement-Maintenance Database System*. doi: 10.17226/24665.

Woodward, D. *et al.* (2016) 'The wear of Stone Mastic Asphalt due to slow speed high stress simulated laboratory trafficking', *Construction and Building Materials*. Elsevier Ltd, 110, pp. 270–277. doi: 10.1016/j.conbuildmat.2016.02.031.

X. Qiu, W. W (2009) ‘Laboratory performance evaluation on polymer modified porous’, GeoHunan International Conference.

Y. Zhang, M. V (2012) ‘Increasing the service life of porous asphalt with rejuvenators’, Sustain. Constr. Mater, 316-328.

Yalcinkaya, C (2009) ‘Porous asphalt’, Department of Civil Engr, Univ. of Dokus Eylul, Tech.

Yildirim, Y (2007) ‘Polymer modified asphalt binders’, Construction and Building Materials, 66-72.

Yadykina, V. *et al.* (2015) ‘The influence of stabilizing additives on physical and mechanical properties of stone mastic asphalt concrete’, *Procedia Engineering*. Elsevier B.V., 117(1), pp. 376–381. doi: 10.1016/j.proeng.2015.08.181.

Zulhaidi, M. J. *et al.* (2018) ‘An Exploration of Weather Threats to Road Safety in Tropical Country’.